TURNING POINT

November 1998

U.S. Industrial Electric Motor System Market Assessment Completed—First of a Kind in 20 Years

The final report of the *United States Industrial Electric Motor Systems Market Opportunities Assessment* is just one phone call away. For the last several years, Motor Challenge has sponsored this comprehensive assessment of motor-driven system use in the industrial sector. Specifically, the market assessment set out to:

- Develop a detailed profile of the current stock of motor-driven equipment in U.S. industrial facilities.
- Characterize and estimate the magnitude of opportunities to improve the energy efficiency of industrial motor systems.
- Develop a profile of current motor system purchase and maintenance practices.
- Develop and implement a procedure to update the detailed motor system profile on a regular basis using readily available market information.
- Develop methods to estimate the energy savings and market effects attributable to the Motor Challenge Program.

How does this information help industry? The report provides a detailed and highly differentiated portrait for manufacturers, distributors, engineers, and other suppliers of motor systems of their end-use markets. In turn, factory managers can use the information in this study to identify

(continued on page 2)

A Motor Challenge
Bimonthly Publication
www.motor.doe.gov

WINNER
APEX '98
AWARDS FOR
PUBLICATION EXCELLENCE

IN THIS ISSUE

Just When You Thought It Couldn't Get Any Better...

Motor Challenge releases online the new MotorMaster+3.0 (MM+3.0)—the upgraded version of the popular MotorMaster+2.01. Available now through the Motor Challenge homepage and soon to be released on CD-ROM, MM+3.0 will make it easier for your motor systems to receive the A+ rating they deserve in the school of efficiency. It is easy to use and learn so you won't have to waste precious hours on the job figuring out how it works—it even comes equipped with a training course.

Now MotorMaster+ 3.0 is available online, with many new features and network compatibility.

The new MM+3.0 is network compatible, which means it can be installed on your company's local or area-wide network, and anyone with access to that network can use it. This feature allows multiple users to simultaneously view, edit, and update corporate- or facility-level motor inventory databases. But that's not all. MM+3.0 sports:

- **New variable load capabilities.** Now, users can enter field measurements and percentage of operating time for up to six motor operating points or load bins; MM+ then will determine the motor load and efficiency at each load point

(continued on page 6)

TURNING POINT
is published bimonthly by the U.S. Department of Energy's (DOE) Motor Challenge Program.

COMMENTS?

Contact:

Julia Oliver, DOE, at (510) 637-1952, or e-mail julia.oliver@oak.doe.gov

Erika Ericksen, *Turning Point* Editor, at (303) 275-3914, or e-mail erika_ericksen@nrel.gov
1617 Cole Blvd., MS 1713
Golden, CO 80401

U.S. Industrial Electric Motor System Market Assessment Completed

continued from page 1

motor system energy savings opportunities in their facilities and to benchmark their current motor system purchase and management procedures against concepts of best practice.

During 1997, XENERGY, on behalf of the Department of Energy, conducted on-site surveys of 265 industrial facilities. The survey was carried out in 20 metropolitan areas nationwide with additional sites in non-metropolitan areas. Trained field engineers, accompanied by a plant representative, collected detailed information about every motor-driven system they could observe that was used in the production process. At each plant, the field engineer worked with plant personnel to take instantaneous load measurements on a sample of motors. These measurements were used to estimate average part loads—a key element in estimates of energy use and potential savings. Detailed information was compiled on over 29,000 motor systems, and load measurements were taken on nearly 2000 motor systems.

In addition, the assessment team collected information on the prevalence of actions identified by industry experts as "good practice" in facilities, since achievement of significant increases in motor system efficiency depends to a large extent on the adoption of good design, purchase, and management practices. Information needed to model the change in the motor systems inventory over time was also collected.

This final report summarizes recently collected information and draws on the results of research that is presented in the Interim Report of the Market Assessment. The Interim Report reports on the extensive review of secondary sources and reanalysis of primary data sets, including results of industrial facilities audits by utilities, motor system engineering studies, and the DOE Industrial Assessment Center program database.

This issue of *Turning Point* highlights the key findings of the Market Assessment. Future issues will profile motor systems and energy use in selected industries, as presented in the report.

Copies of the United States Industrial Electric Motor Systems Market Opportunities Assessment *will be available in **January 1999**. Call the Motor and Steam Challenge Information Clearinghouse starting in January at (800) 862-2086 to place your order.*

Market Assessment Reveals Key Facts on Motor Systems

- *Industrial motor systems represent the largest, single, electrical end use in the American economy—25% of the Nation's electricity.*
- *Potential industrial motor system energy savings using mature, proven, cost-effective technologies in the manufacturing sector can be as high as 18% of current annual usage or 122 billion kWh per year, which is equal to the annual electricity use in the state of New York.*
- *Improvements to the major fluid systems—pumps, fans, and compressors—represent up to 62% of potential savings.*
- *For industries that use significant amounts of motor systems energy, the financial impact of motor system energy costs and potential savings are substantial—representing 1% to 10% of operating margin.*
- *The potential savings for a typical facility are around $90,000 per year; for paper mills, petroleum refineries, and inorganic chemical plants (the three highest motor system energy consuming industry groups) the annual savings are $659,000, $946,000, and $283,000 per establishment, respectively.*
- *The magnitude and patterns of motor systems energy use and potential savings vary greatly among industries.*
- *Except in large facilities, the level of knowledge and implementation of systematic approaches to motor system energy efficiency is low.*

Louisiana Pacific's Motor Challenge Showcase Demonstration Project Achieves Substantial Savings with Simple Modifications

Do you think, like many others, that energy efficiency measures are just too costly and complex to be practical? Well, think again. The Louisiana Pacific (LP) plant in Tomahawk, Wisconsin, proves that a typical company can implement relatively low-cost, simple changes to realize significant energy and dollar savings.

By carefully analyzing its oriented strand board (OSB) processing system, evaluating energy saving opportunities, and adjusting the system for optimal performance, LP achieved electrical cost savings of $85,000 and energy savings of nearly 2,436,000 kWh—translating into a 40% improvement from the baseline annual energy use of 5.7 million kWh. The project costs were $44,000, making the simple payback period about 6 months.

LP's Tomahawk plant produces OSB from Wisconsin grown aspen trees and markets it in 4' x 8' sheets to the construction industry. At this facility, LP operates two parallel, automated process lines. One line prepares wood for the outer OSB surface (the surface dryer system), while the other prepares wood for the core (the core dryer system).

The process of making OSB begins with debarking the aspen logs and shaving them into "flakes." A 350-hp induced draft (ID) fan draws the flakes through a rotary drum dryer to remove moisture and cure the wood. A cyclone separator isolates the usable flakes from the unusable. Unusable fines are burned to provide heat for the drum dryers, while usable pieces are saturated with resin, assembled into layers, and compressed into boards of various thicknesses. Meanwhile, a secondary ID fan draws moist, chemical-laden air from the system through an electrostatic scrubber called the E-tube and then out of the plant. The fans see a varying system load, so the airflow and power draw varies.

Hoping to find ways to improve the performance of both process lines, LP worked with the Energy Center of Wisconsin and Wisconsin Public Service on this Showcase Demonstration project. The company enlisted Waterloo Air Specialists to perform a feasibility study and make optimization recommendations. Wisconsin Public Service contributed $5,000 toward the initial project feasibility by Waterloo, slightly reducing LP's project implementation costs.

The analysis focused on identifying ways to eliminate elements in the system that were causing undo pressure drop and lower fan operating speeds to reach the required process flow. Energy would be saved by supplying the same flow but at a reduced static head.

Based on the results of the analysis, LP performed the following modifications to three fan systems on each of the process lines:

Dryer Induced Draft Fan: Fully opened flow damper and replaced the 350-hp electric motor with a 200-hp, high-efficiency electric motor. Reduced fan speed from 1100 rpm to 700 rpm.

Combustion Air Fan System: Removed the control damper and replaced the 125-hp electric motor with a 40-hp, high-efficiency electric motor. Reduced fan speed from 2400 rpm to 1400 rpm.

Louisiana Pacific's low-cost fan optimization project makes its oriented strand board process more efficient.

Scrubber Induced Draft Fan: Fully opened flow damper and controlled airflow by an inlet vane controller. Fan speed was not changed.

After the changes, LP conducted follow-up measurements and noted significant energy and cost savings. The modifications to the dryer induced draft fan system contributed 40% of the cost savings, the combustion air fan system 52%, and the scrubber fan 10%.

Other companies can discover that implementing energy efficiency measures yield excellent results and can be surprisingly simple to do.

For copies of Showcase Demonstration case studies, contact the Motor and Steam Challenge Information Clearinghouse at (800) 862-2086.

Water/Wastewater Energy Efficiency Forum a Success

From August 30 to September 1, Motor Challenge helped ensure that the WaterWorld/EPRI Energy Efficiency Forum for the Water and Wastewater Industry was a success to all who participated. To kick off the event, Motor Challenge held a preconference workshop on Performance Optimization for Pumping Systems. It was attended by over 60 water/wastewater professionals. The following 2 days consisted of several sessions on topics such as the changing power market, energy management, energy audits, pumping technology, aeration optimization and case studies, motor systems, and power generation.

The forum included presentations on the resources available through the Motor Challenge Program, the program's efforts with the water and wastewater industry, and the MotorMaster+ software. In addition, Motor Challenge distributed materials and demonstrated MotorMaster+ on an ongoing basis. The keynote speech on August 31 by Amory Lovins of the Rocky Mountain Institute was a big hit among the more than 100 participants at the forum.

The 3-day event equipped attendees with valuable information to help them improve the efficiency of their water and wastewater systems. Those in the water and wastewater industry should plan on attending next year's forum, which WaterWorld is already planning, and in which Motor Challenge will be a full cosponsor. Check out future issues of *Turning Point* for the dates.

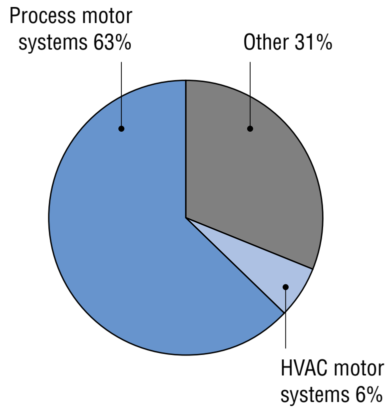
A GLIMPSE AT WHAT'S BETWEEN THE COVERS OF THE MARKET ASSESSMENT

Industrial Motor Systems are the Largest Single Electrical End Use

In 1994, motor systems used only for production processes consumed 679 billion kWh or 23% of all electricity sold in the United States that year. Add the energy associated with industrial heating, ventilation, and air conditioning systems, and the total jumps to 747 billion kWh or 25% of all electric sales.

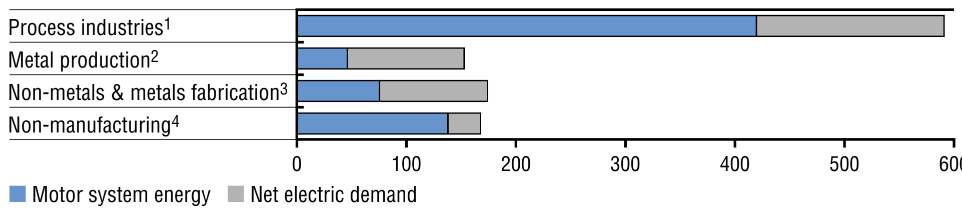
Therefore, all types of motor systems account for 69% of all industrial electricity consumption. For the distribution of motor system energy use by major industry group, refer to the following chart.

Electricity Used in Industry



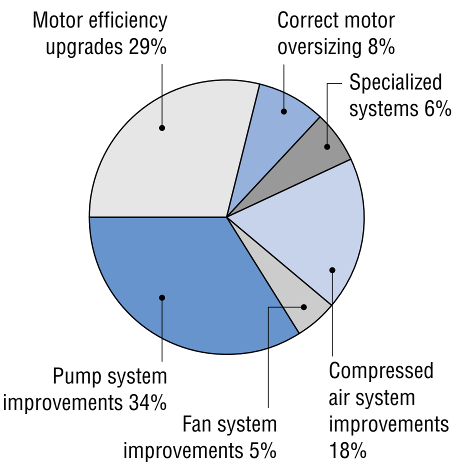
Industrial Motor System Energy Use*

In billions of kilowatt hours



[1]SICs 20, 21, 22, 24, 26, 27, 28, 29, 30, 31, 32. [2]SIC 33. [3]SICs 23, 25, 34, 35, 36, 37, 38, 39.
[4]SICs 01, 02, 10, 12, 13, 14, 494, 4952, 4971.
*This graph does not reflect HVAC motor system energy use in these sectors.

Breakdown of Motor System Savings in the U.S. Manufacturing Sector



Based on instantaneous load measurements of nearly 2000 motors operating under normal conditions, the market assessment team found that over 40% of them were operating at part load, below 40% full motor nameplate load. By better matching the motor to the load, companies can achieve substantial savings.

Save More than 10% with Motor System Improvements

It's time to take advantage of the opportunities for motor system improvements in your manufacturing facility. According to data collected during the Market Assessment survey, potential motor system energy savings across all U.S. manufacturing using mature, proven, cost-effective technologies range from 11% to 18% of current annual motor system energy use or 75 to 122 billion kWh per year. In dollar figures, the savings amount to $3.6 billion to $5.8 billion annually. For some specific facilities and systems, Motor Challenge, through its Showcase Demonstration case studies, has documented savings of 33% to 59%, far exceeding the industry average.

The following table shows how potential savings are distributed among different kinds of measures and end uses in manufacturing only. Nearly two-thirds of all potential savings derive from system improvements, such as substituting adjustable speed drives for throttling valves or bypass loops in pumping systems and fixing leaks in compressed air systems. Improvements to major industrial fluid systems—pumps, fans, and air compressors—present up to 62% of all potential savings.

In addition to energy savings, improvements result in many economic benefits such as increased control over manufacturing processes and improved quality control.

Summary of Motor Energy Savings Opportunities by Measure in Manufacturing Facilities

Measure	GWh	% of Total Motor System Energy
Motor Efficiency Upgrades	24,577	4.3%
Systems Level Efficiency Measures		
Correct Motor Oversizing	6,786	1.2%
Pump Systems:		
System Efficiency Improvements	13,698	2.4%
Speed Controls	14,982	2.6%
Pump Systems: Total	28,681	5.0%
Fan Systems:		
System Efficiency Improvements	2,755	0.5%
Speed Controls	1,575	0.3%
Fan Systems: Total	4,330	0.8%
Compressed Air Systems:		
System Efficiency Improvements	13,248	2.3%
Speed Controls	2,276	0.4%
Compressed Air Systems: Total	15,524	2.7%
Specialized systems: Total	5,259	0.9%
Total System Improvements	60,579	10.5%
Total Potential Savings	85,157	14.8%

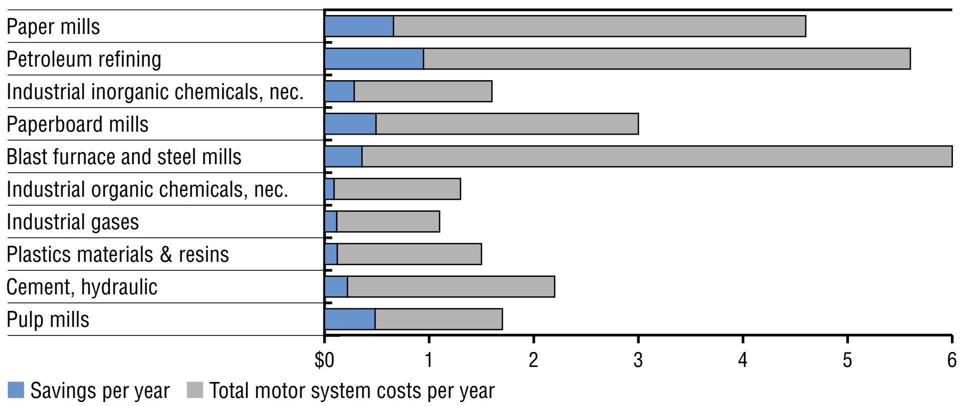
Motor System Energy Use and Savings is Highly Concentrated in 10 Industries—Is Yours One of Them?

The industries listed in the table below account for nearly half of all manufacturing motor system energy use and half of all potential motor system energy savings. They include only 3583 facilities or 1.5% of all manufacturing plants. In all these industries, the annual cost of motor system energy in a typical plant exceeds $1 million. In steel mills, for example, the cost is $6 million. Because these industries use large amounts of motor system energy, they also have the opportunity to achieve large energy savings. Potential savings range from $90,000 annually in the industrial organic chemicals sector to nearly $1 million annually in petroleum refineries.

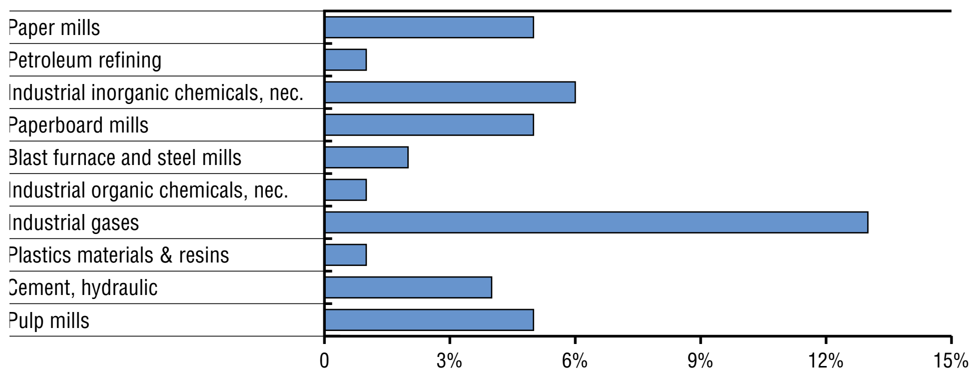
What does all this mean for your company's bottom line?

The process industries listed here operate on very thin margins. In 1996, the operating margins for these groups were around 16%, so even relatively small increases in operating margin can significantly impact profitability.

Financial Impact of Motor Energy Consumption and Savings per Establishment
In millions



Motor System Savings as a Percent of Operating Margin



Findings on Current Motor Systems Design, Purchase, and Maintenance Practices

- *Most motor purchase designs are made at the plant level.*
- *Only 19% of respondents reported being aware of "premium efficiency" motors, the common market designation for motors that meet standards promulgated in the Energy Policy Act. Only 4% of customers reported understanding the efficiency ratings associated with the premium or high efficiency designations, whereas 38% reported being somewhat aware of these relationships.*
- *Only 22% of customers surveyed reported that they had purchased efficient motors in the past year.*
- *Customers most often use the size of a failed motor being replaced as a key factor in deciding the size of the new motor. And 29% use the size of the failed motor as the only factor in the sizing decision. This practice can lead to persistent oversizing of motors, which leads to inefficient operations.*
- *Only 11% of customers interviewed reported having written specifications for motor purchases, and only two-thirds of those customers included efficiency in their specifications.*
- *Reducing capital costs is the most important consideration driving customers' decision whether to rewind or replace failed motors.*
- *The frequency with which system-level improvements are undertaken is low, except among the largest facilities.*

Take the Systems Approach to Energy Efficiency and Save

Over the last 5 years, industrial engineers and plant managers have begun to formulate and articulate a systematic approach to achieving energy efficiency in motor systems. Motor Challenge has joined forces with electric utilities, trade and professional organizations, and government agencies to promote this approach. The systems approach can be broken down into three elements:

- system performance optimization
- efficient components selection
- operation and maintenance practices

Turn to the Market Assessment for examples of the systems approach to efficiency measures in pump, fan, and compressed air systems. Here's an example of what you'll find.

Energy Saving Opportunities in Pump Systems

Equipment Group/Efficiency Measure	Savings (Percent of System Energy)
Process System Design	
Reduce Overall System Requirements	
■ Equalize flow over production cycle using holding tanks.	10%-20%*
■ Eliminate bypass loops and other unnecessary flows.	10%-20%†
■ Increase piping diameter to reduce friction.	5%-20%†
■ Reduce safety margins in design system capacity.	5%-10%†
Match Pump Size to Load	
■ Install parallel systems for highly variable loads.	10%-30%†
Reduce or Control Pump Speed	
■ Reduce speed for fixed loads; trim impeller, lower gear ratios.	5%-40%†
■ Replace throttling valves with speed controls to meet variable loads.	5%-50%†
Component Purchase	
■ Replace typical pump with efficient model.	1%-2%
■ Replace belt drives with direct coupling.	About 1%
■ Replace typical motor with most efficient model.	1%-3%
Operation and Maintenance	
■ Replace worn impellers, especially in caustic or semi-solid applications.	1%-5%

*Depending on variation in flow.
†Depending on initial system design.

MotorMaster+3.0 Gets Even Better

continued from page 1

and compute a time-weighted load and average operating efficiency.

- **Improved motor load and efficiency estimation capabilities.** Users will find seamlessly integrated into MM+3.0, the Oak Ridge Motor Efficiency and Load (ORMEL) 96 program. ORMEL 96, developed by the Department of Energy's Oak Ridge National Laboratory, determines both motor load and efficiency whenever nameplate information and operating speed measurements are available.
- **Updated efficiency default values.** The software's Compare Motor Replacement Analysis module contains updated "generic" energy-efficient and premium efficiency motor full and part-load efficiency default values.
- **An updated manufacturer's catalog motor database.** This database contains current (1998) price and performance data for post-EPAct motor model lines. And it is downloadable to your home or office computer. You can be sure that you are getting the most cost-effective motor for the application.

Recognizing that hours spent fumbling through user guides can translate into dollars wasted for your company, Motor Challenge has created an interactive training course on MM+3.0. The training, available only on CD-ROM, is made up of five modules and is designed to help you become proficient in MM+3.0. It includes step-by-step exercises and presents problems for you to solve using the software. With Windows, you can run the training lesson and MM+ at the same time. As you read the lesson, you can switch to MM+ with the stroke of a key, and try out what you just read. To see how much you've learned, there is a final quiz. You can order the training course on CD-ROM from the Motor and Steam Challenge Clearinghouse at (800) 862-2086 beginning in December.

The online version of MM+3.0 is available on the new MotorMaster+ Web site **(www.motor.doe.gov/mmplus)**, where users can also register and download a copy of the software. In addition, the new Web site allows motor manufacturers to upload current data on their motors for incorporation into the motors database. Users have several opportunities on the site to subscribe to the MM+ listserve and be notified of updates to the motors database, software upgrades, and other helpful news. There is also a User Help & Frequently Asked Questions feature.

Performance Optimization Tips

How to Cope with Potential Field Measurement Pitfalls

By Don Casada, Motor Challenge Program, Oak Ridge National Laboratory

All useful assessments of efficiency and reliability depend on measuring the right things in the right way. While this observation could apply to individuals or organizations, it most certainly applies to motor systems.

In any motor system, there are different levels and types of information that need to be acquired. Both quantitative and qualitative data are needed. This article is the first in a series dealing with potential pitfalls in assessing motor system efficiency with an emphasis on field monitoring. The articles will focus on (1) seeing the big picture first, (2) what to do when the picture changes, and (3) how to handle the devils in the details.

Seeing the Big Picture First

Engineers, like myself, can become preoccupied with details. We have a natural affinity for taking measurements, then plotting and analyzing the data. While there's a place for that, the first order of business should be at a higher level. Let's use an example to illustrate just how important this is.

We're on the plant's newly formed energy improvement team. Recognizing that centrifugal devices like pumps and fans are our biggest electrical energy consumers, we immediately go after the pump and fan systems. We develop an inventory of the plant's motors that are 10 hp and above. We estimate the annual operating times for each of the motors. Then we carefully analyze the top 20% (by the product of size and operating time).

One of those systems is an air exhaust system in a machine shop area. We discuss system operations with the machine shop supervisor. He verifies that they conscientiously turn off the exhaust fan on weekends. We do note that the fan is left running during mealtimes and at breaks, accounting for about 2 hours a day (8%) of the total operating time. Savings identified, and we haven't even taken data yet!

Next, equipped with calibrated instruments, we measure flow rate; head, fan, and motor speeds; and motor input power. Armed with the raw data, we now make calculations and retrieve vendor performance curves. When we compare our performance results with the vendor curves, we find that the fan is actually operating very near its best efficiency point (BEP). But having noted that a fan discharge damper was throttled, we do some further calculations and point out that there is an opportunity to reduce fan energy consumption by 9% by resheaving to reduce the fan speed and then opening the damper.

We note that the existing motor is 20 years old and has been rebuilt once. Using the MotorMaster database, we estimate that we can gain 3% in motor efficiency. Recognizing that the new motor will run a little faster than the old one, we adjust the sheave size to match the speed of the new motor. The total savings are up to a quite impressive 20%. We document our findings and recommendations, gain management approval, allocate capital funds, and set aside a day to make the motor and sheave swap. Finally, we make some post-modification measurements. The data matches precisely with what we predicted, validating the savings. We also verify that the fan is operating right on its BEP. After a few high-fives, we move on to conquer the next dragon.

But not so fast. Unfortunately, we missed an opportunity for an 80% to 90% reduction in energy consumption instead of a 20% one. To show how easily this happens, let's contrast our situation with commodities in a free economy marketplace.

In the marketplace, if a customer's demands for a commodity aren't being met, there is usually quick action to make changes to keep up with the demand. Likewise, if a motor system isn't meeting its demand, the facility operators and management will be keenly aware of its shortcomings, and it will get quick attention.

But what about excesses? The supply and demand laws dictate that if there is more supply than demand, prices will drop and there will be a natural balancing. What happens if a motor system exceeds demand? The answer is "It depends." If the motor system under consideration involves product movement on a conveyor belt, there will always be some action taken—either the line will be stopped or its speed reduced. But in other types of systems there may be no action taken at all because there are no self-evident forces to balance supply and demand.

Which brings us to our fan system and the significantly greater savings opportunity we have missed. If our exhaust fan was removing air at twice the rate actually needed for the machine shop, would anyone complain? Not usually, unless the noise was aggravating or sucking change out of the machinists' pockets. But the fan would be doing several times as much work as necessary (the ideal power is proportional to the flow rate times head, and there would be more head required due to frictional losses attendant with the higher flow rate). By using a smaller fan, perhaps outfitted with an adjustable speed drive if process flow requirements change with time (or maybe a group of small fans that could be turned on and off as needed), the overall power requirements could be reduced by almost an order of magnitude.

Does that mean the existing fan is operating inefficiently? It absolutely does not; in fact we just made sure that it was near its BEP. The fact is that the fan and motor efficiencies are outstanding, but the system efficiency—measured as the demand divided by the supply—is atrocious. We might further note that temperature and/or humidity conditioning of the excess air would further compound the waste.

The importance of avoiding two major pitfalls in performing system optimization assessments are illustrated through the example we've discussed:

(1) Never assume that the system operating point is the same as what the system really needs. Think about the fundamental need that is being met, not about the details of the existing system. (2) Never assume that good individual component efficiency equates to good overall system efficiency.

Many of the subjects discussed are based on the author's personal education in the field. Readers may send questions, comments, or suggestions (such as field measurement lessons learned you'd like to share) to Don Casada at:

E-mail: A85@ornl.gov
Phone: (423)576-4271
Fax: (423)576-0493

Coming Events 1999

Get Ready to Turn Your Visions into Reality

The Third Industrial Energy Efficiency Symposium and Exposition, “Turning Industry Visions into Reality,” is set for February 7-9,1999, in Washington, D.C. Mark your calendar to attend this national conference on energy efficiency and clean manufacturing in U.S. industry. The event will highlight leading-edge thinking and advanced technologies to meet emerging energy, environmental, and market demands. Check out the Web page at www.oit.doe.gov for current information on this conference, or call (877) OIT-SYMP.

Attend the Electric Motor Predictive Maintenance Conference

The Electric Power Research Institute is holding a two-day conference February 8-10, 1999, that will focus on exchanging information about the application of electric motor predictive maintenance. Formal papers will be presented in the general session and small group discussions will be held on topics selected by the attendees. There will also be tutorials on electrical and mechanical subjects. The conference will take place in Orlando, Florida. For information, call Megan Boyd at (650) 855-7919.

This document was produced for the Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory, a DOE national laboratory.
DOE/GO-10098-586 • November 1998

Information Clearinghouse

Do you have questions about using energy-efficient electric motor systems? Call the Motor and Steam Challenge Information Clearinghouse for answers, Monday through Friday 9:00 a.m. to 8:00 p.m. (EST).

HOTLINE: (800) 862-2086

Fax: (360) 586-8303, or access our homepage at www.motor.doe.gov

Motor Challenge Management Team

- Paul Scheihing, Program Manager
- Julia Oliver, Communications
- Chris Cockrill, Product and Service Development
- Richard Been, Program Operations

DOE Regional Support Office Representatives

- Tim Eastling, Atlanta, GA, (404) 347-7141
- Lili Griffin, Boston, MA, (617) 565-9734
- Julie Nochumsom, Chicago, IL, (312) 886-8579
- Gibson Asuquo, Denver, CO, (303) 275-4841
- Julia Oliver, Seattle, WA, (510) 637-1952
- Maryanne Daniel, Philadelphia, PA, (215) 656-6964

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste

TURNING POINT

The Motor Challenge
EE-20, 5G-067
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585